AQDJJ - Short Visit Grant - Final Report

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Superconducting Qubits and Circuit QED

The purpose of my visit to the Physics Department at the Ludwig-Maximilians-Universität in Munich was to become familiar with the theory and techniques used in the emerging field of circuit Quantum Electrodynamics (QED) [1-3], where superconducting qubits [4] are coupled to microwave coplanar waveguides reproducing an analog to the field of cavity QED in quantum optics [5]. It has been recently shown that the coupling of cavity modes with a variety of superconducting qubits, also called "artificial atoms", can lead to interesting quantum effects [6,7], some of which can reach regimes beyond their quantum-optical versions [8], where atoms are coupled to cavities in the microwave [9] and optical [10] regimes.

During my visit, I have focused my research on the connections between quantum optics, superconducting qubits and circuit QED, which are getting stronger and promising. We have studied the possibility of applying the theory of instantaneous measurements of field observables such as phonon-number moments or field quadratures [11-13] to systems of superconducting qubits. In particular we have explored the theory of instantaneous measurements beyond the usual Rotating-Wave Approximation (RWA) when it is applied to superconducting qubits in circuit QED, yielding some interesting phenomena, such as the possibility of measuring counter rotating

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contributions in these systems at very small times. To go beyond the RWA in the Jaynes-Cummings model, a recently developed theory of the generalized RWA [14] has been used.

The relations and connections between instantaneous measurements with the theory of weak measurements [15,16] and the quantum Zeno effect [17] are promising and will be considered in our research. It is our intention to continue this collaboration between the Bilbao and Munich groups, and we plan to submit our work for publication when further results are obtained.

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